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(54) **HYDROCARBON PRODUCTION EQUIPMENT, HYDROCARBON PRODUCTION SYSTEM, CONTROLLER FOR HYDROCARBON PRODUCTION DEVICE, AND METHOD FOR PRODUCING HYDROCARBON**

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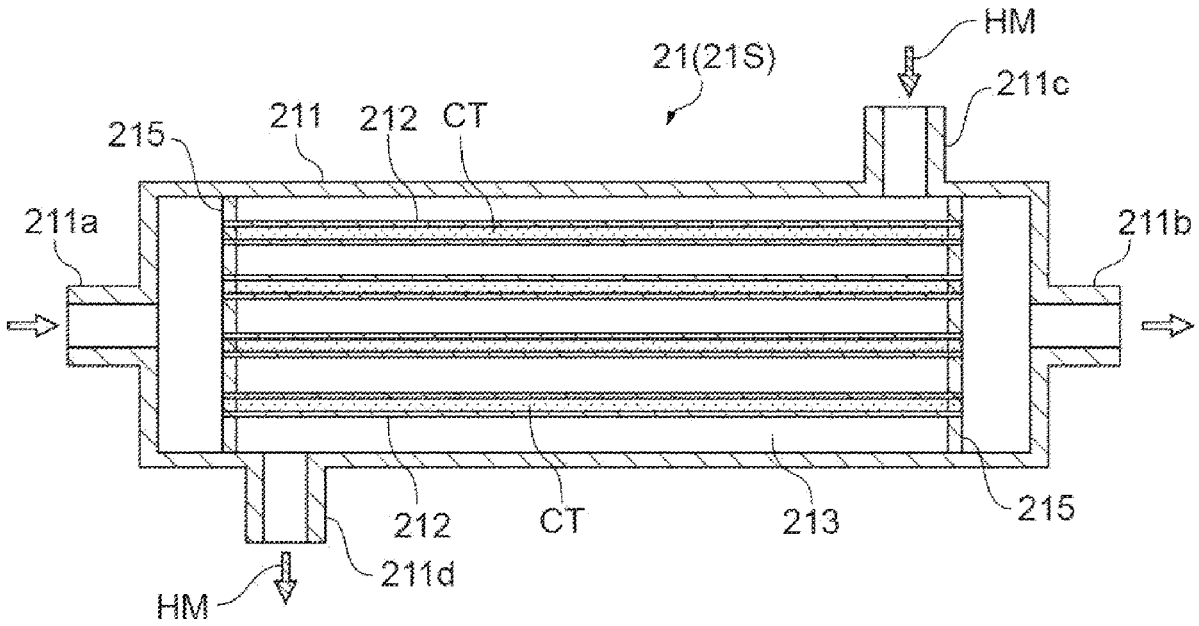
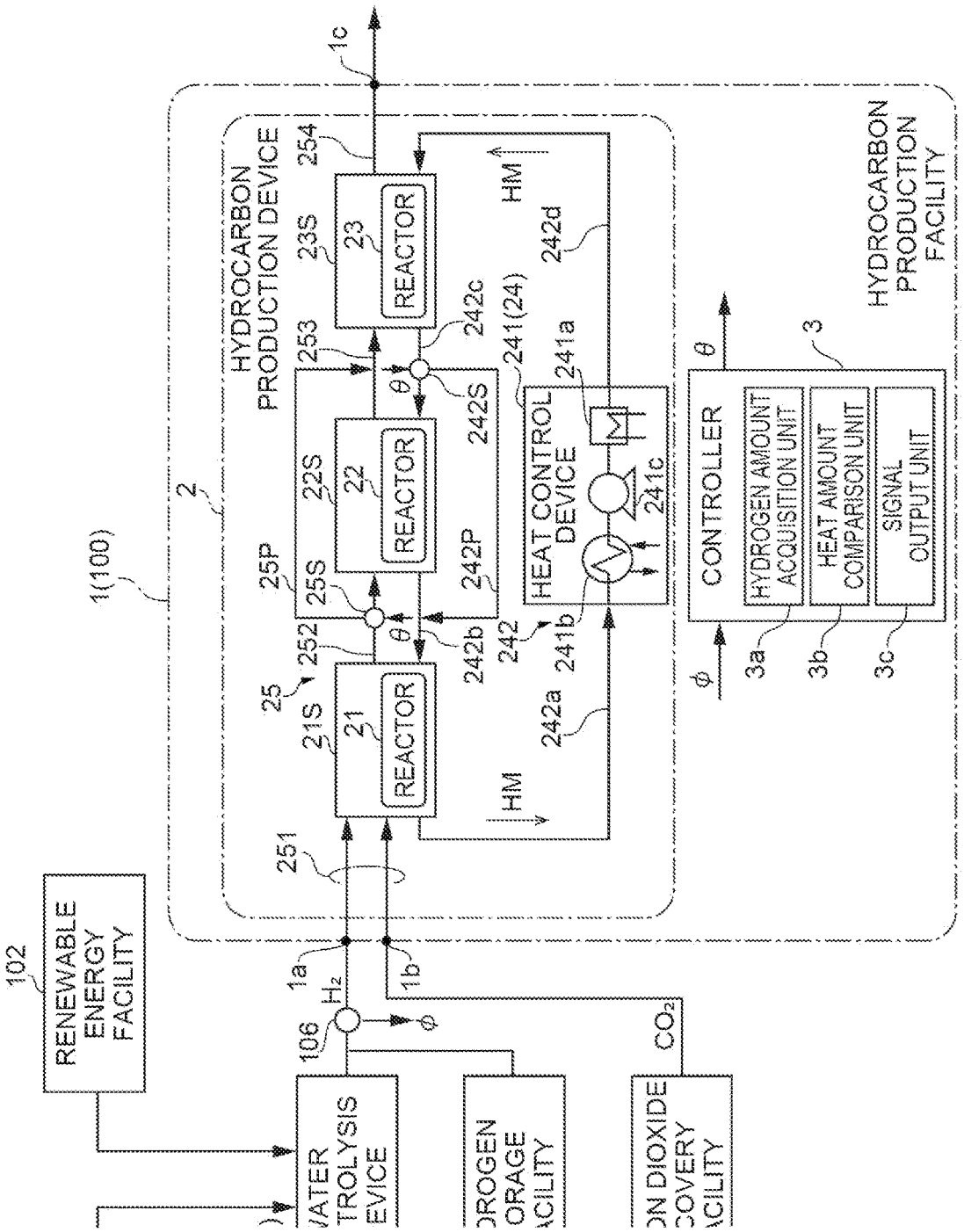
(57) **ABSTRACT**

A hydrocarbon production equipment includes: a first reaction device that receives a source gas and causes the source gas to react by using a catalyst to generate a first intermediate gas; a second reaction device that causes the first intermediate gas to react by using a catalyst to generate a second intermediate gas; a heat supplier that can supply heat for heating the catalyst to a reactor and can supply heat for heating the catalyst to the reactor; and a controller that controls an operation of the heat supplier. The controller selectively outputs a first control signal for supplying heat to each of the first reaction device and the second reaction device and a second control signal for supplying heat to only one of the first reaction device and the second reaction device to the heat supplier. The controller selects any one of the first control signal and the second control signal based on the amount of hydrogen included in the source gas.




1(100)
2
HYDROCARBON PRODUCTION DEVICE
HYDROCARBON PRODUCTION FACILITY
1c
254
23S
23
REACTOR
253
242c
241(24)
242d
HM
θ
242S
22S
22
REACTOR
25P
25S
252
242P
242b
242
HEAT CONTROL DEVICE
241a
241c
241b
CONTROLLER
3
HYDROGEN AMOUNT ACQUISITION UNIT
HEAT AMOUNT COMPARISON UNIT
SIGNAL OUTPUT UNIT
3a
3b
3c
25
21S
21
REACTOR
251
242a
HM
102
RENEWABLE ENERGY FACILITY
1a
1b
H₂
106
ϕ
CO₂
ATER TROLYSIS EVICE
DROGEN ORAGE CILITY
ON DIOXIDE COVERY CILITY

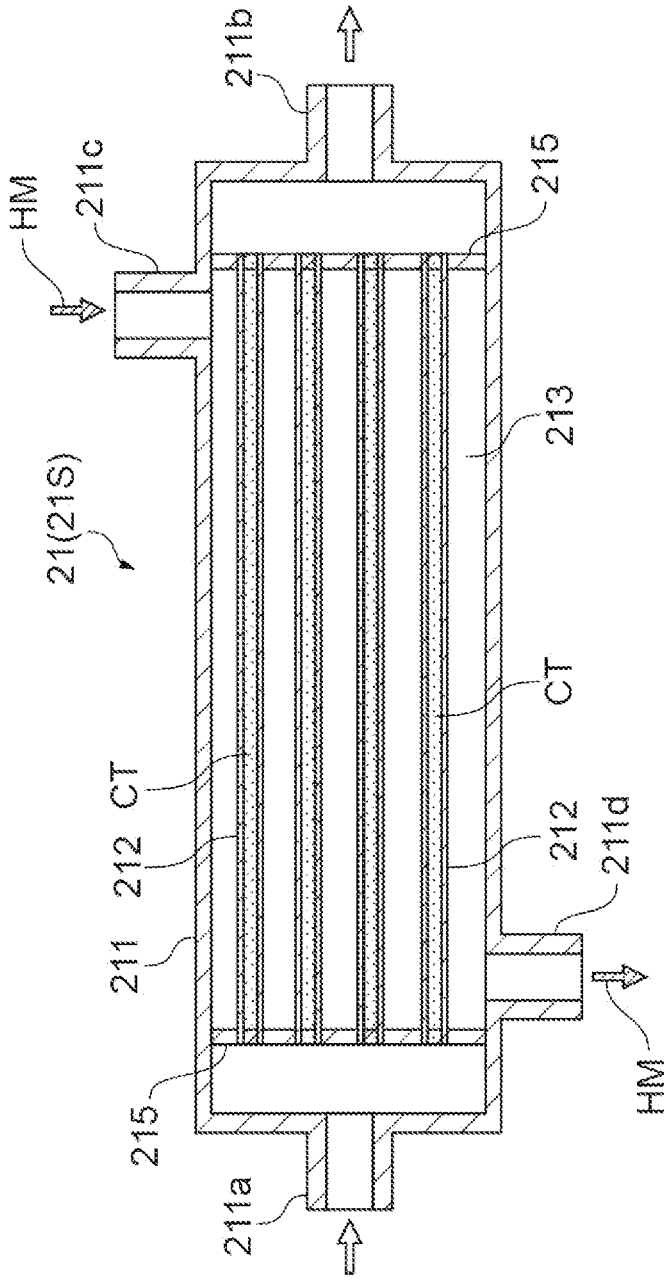


Fig.2

Fig.3

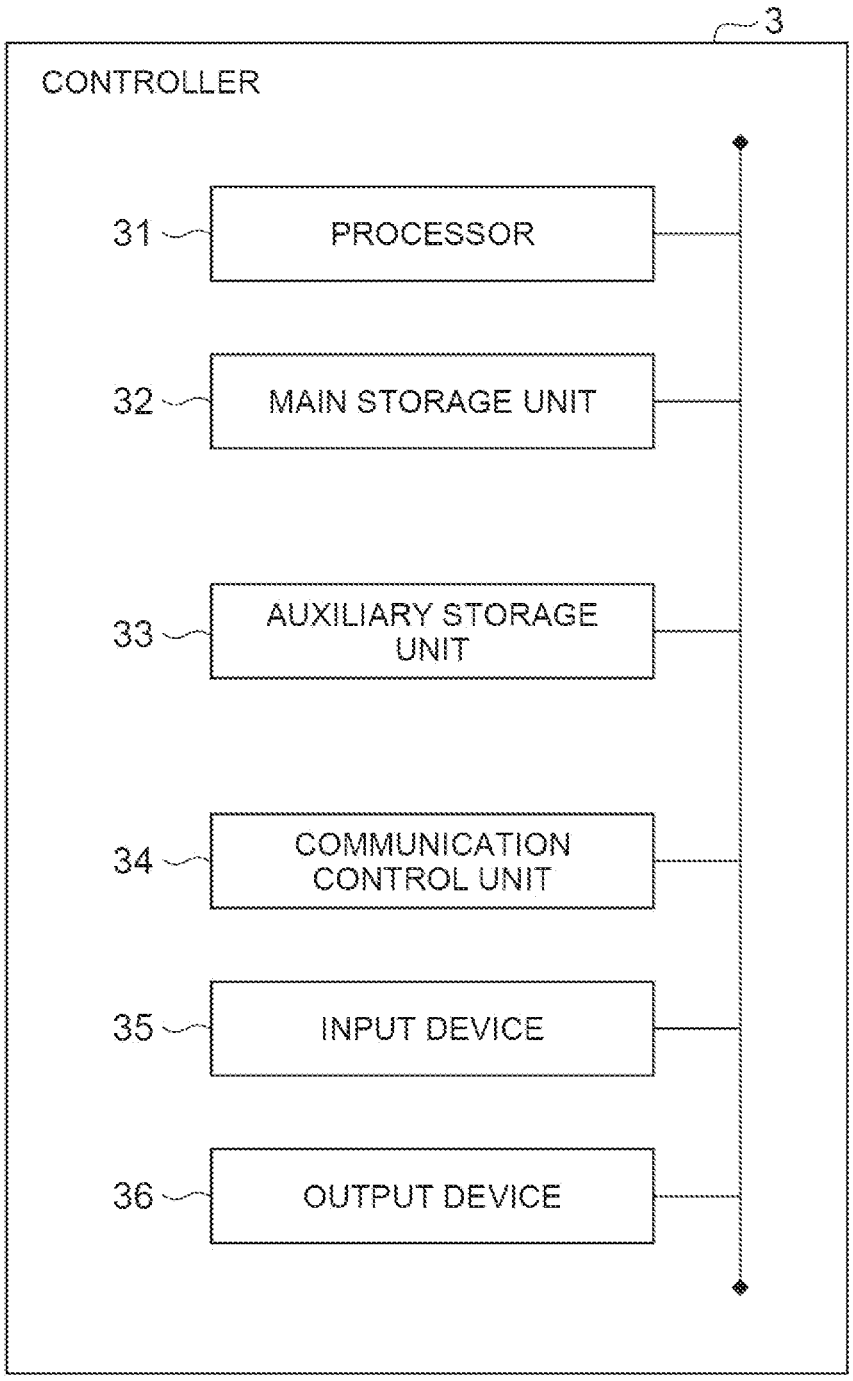
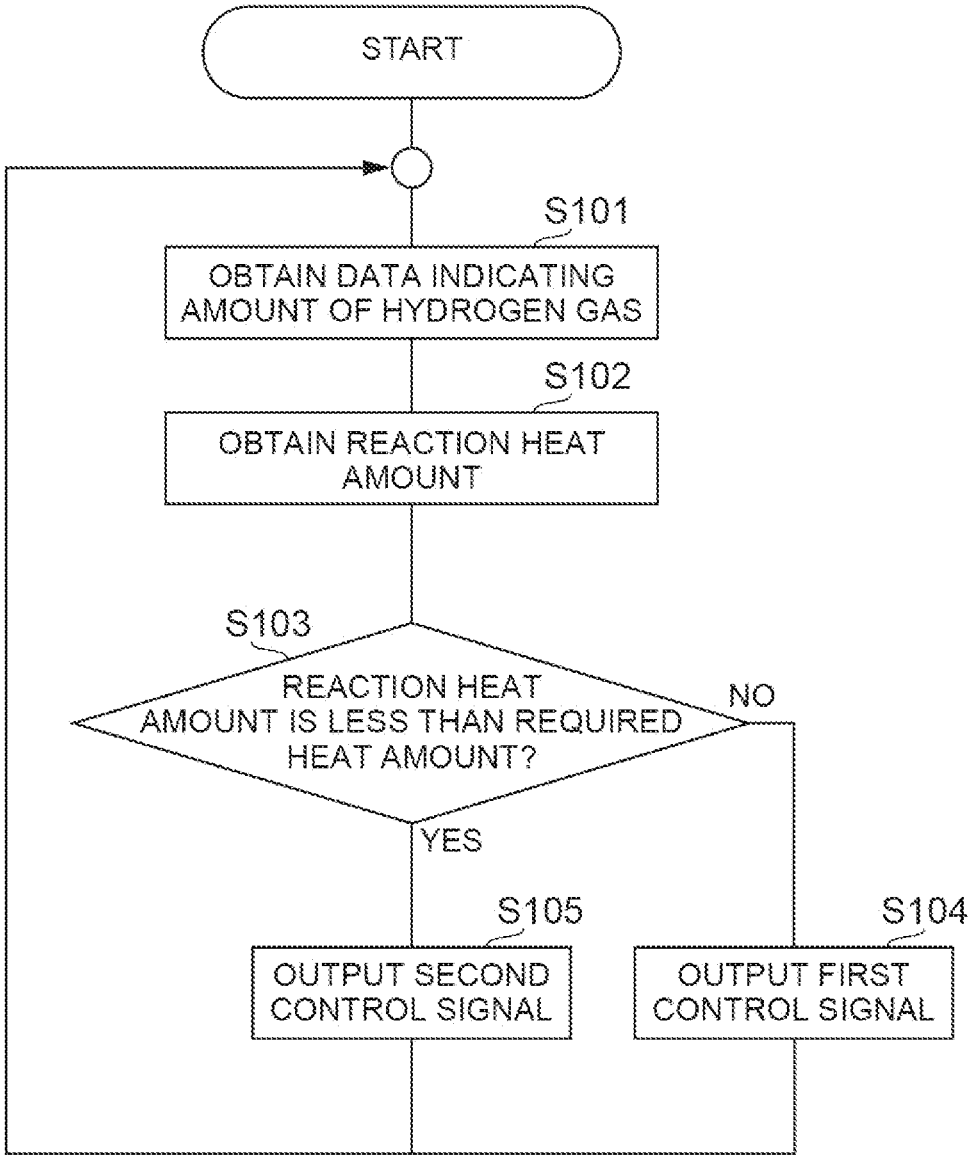

3
CONTROLLER
31
PROCESSOR
32
MAIN STORAGE UNIT
33
AUXILIARY STORAGE UNIT
34
COMMUNICATION CONTROL UNIT
35
INPUT DEVICE
36
OUTPUT DEVICE

Fig.4


START
S101
OBTAIN DATA INDICATING AMOUNT OF HYDROGEN GAS
S102
OBTAIN REACTION HEAT AMOUNT
S103
REACTION HEAT AMOUNT IS LESS THAN REQUIRED HEAT AMOUNT?
NO
YES
S105
OUTPUT SECOND CONTROL SIGNAL
S104
OUTPUT FIRST CONTROL SIGNAL

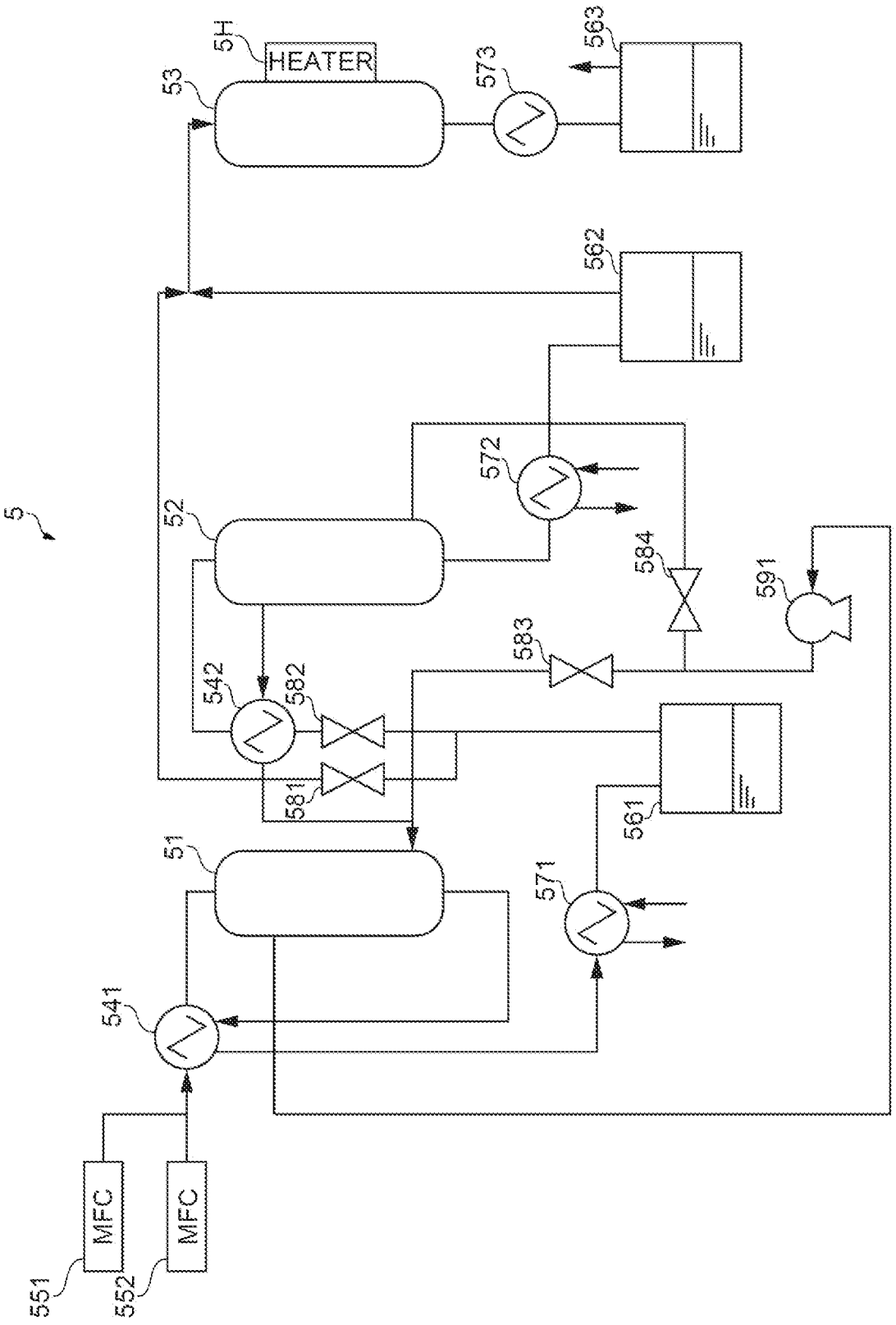
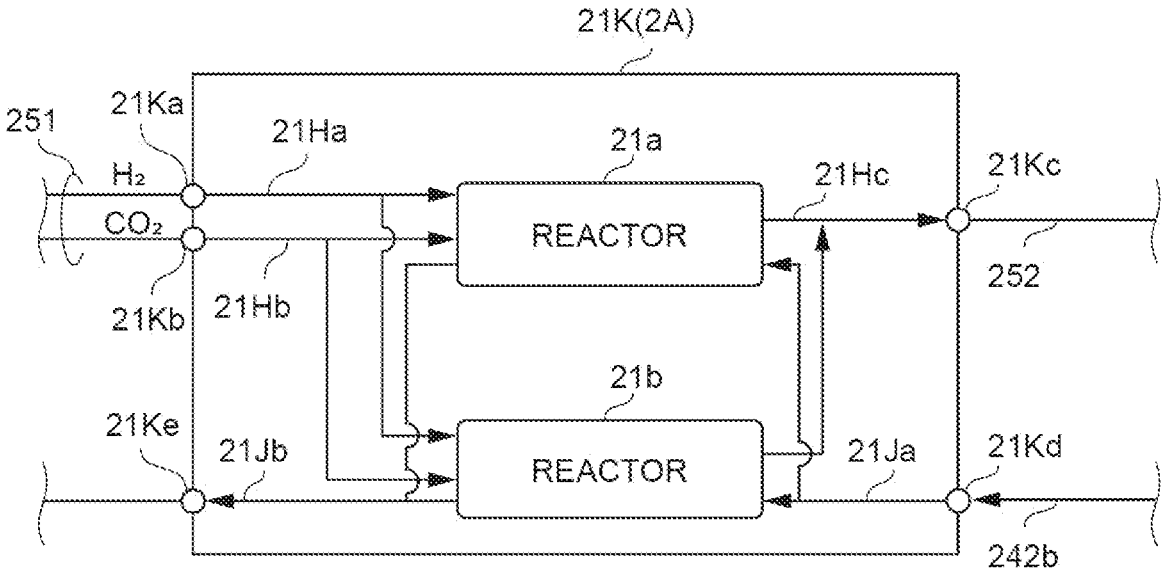

5
5H
HEATER
53
573
563
562
572
52
584
591
583
542
582
581
561
51
571
541
MFC
MFC
551
552

Fig.5

Fig.6


21K(2A)
251
21Ka
21Ha
21a
21Hc
21Kc
H₂
CO₂
REACTOR
252
21Kb
21Hb
21b
21Ke
21Jb
REACTOR
21Ja
21Kd
242b

HYDROCARBON PRODUCTION EQUIPMENT, HYDROCARBON PRODUCTION SYSTEM, CONTROLLER FOR HYDROCARBON PRODUCTION DEVICE, AND METHOD FOR PRODUCING HYDROCARBON

TECHNICAL FIELD

[0001] The present disclosure relates to a hydrocarbon production equipment, a hydrocarbon production system, a

equipment using renewable energy is also likely to fluctuate. As a result, when the amount of hydrogen output from the water electrolysis device is not sufficient, it is necessary to supply energy required for the reaction from the outside as described above. Therefore, a state in which it is difficult to improve energy efficiency as a whole may occur.

[0007] The present disclosure describes a hydrocarbon production equipment, a hydrocarbon production system, a controller of a hydrocarbon production device, and a method for producing hydrocarbon that can improve energy effi-

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TECHNICAL FIELD

[0001] The present disclosure relates to a hydrocarbon production equipment, a hydrocarbon production system, a controller of a hydrocarbon production device, and a method for producing hydrocarbon.

BACKGROUND ART

[0002] In recent years, renewable energy is increasingly used. There is a technique of converting surplus power among power generated by renewable energy into an energy medium different from the power and storing the energy medium. For example, water electrolysis technology generates hydrogen as an energy medium by surplus power. By storing hydrogen, surplus power can be stored. Not only a technique for using stored hydrogen alone but also a technique for converting hydrogen into a form that is easy to transport or to use is actively developed.

[0003] The energy medium is not limited to hydrogen. For example, hydrocarbon and ammonia can also be utilized as energy media. A technique for producing hydrocarbon and ammonia by using hydrogen as a raw material attracts attention. Hydrocarbons use hydrogen and carbon dioxide as raw materials. Therefore, it is advantageous in that carbon dioxide is effectively utilized. For example, Patent Literature 1 discloses a technique for producing methane by using hydrogen and carbon dioxide. A device of Patent Literature 1 produces hydrogen using a water electrolysis device using renewable energy. In the device of Patent Literature 1, a part of the reaction step is omitted when load fluctuates. As a result, the state of a reaction is adjusted to be in equilibrium in each step.

CITATION LIST

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[0007] The present disclosure describes a hydrocarbon production equipment, a hydrocarbon production system, a controller of a hydrocarbon production device, and a method for producing hydrocarbon that can improve energy efficiency.

Solution to Problem

[0008] A hydrocarbon production equipment according to an aspect of the present disclosure includes: a first reaction device configured to receive a source gas including hydrogen and carbon and cause the source gas to react by using a first catalyst heated to a predetermined temperature to generate a first intermediate gas including hydrocarbon; a second reaction device configured to cause the first intermediate gas to react by using a second catalyst heated to a predetermined temperature to generate a second intermediate gas including hydrocarbon; a heat supplier configured to be capable of supplying heat for heating the first catalyst to the first reaction device and capable of supplying heat for heating the second catalyst to the second reaction device; and a controller configured to control an operation of the heat supplier. The controller selectively outputs a first control signal for supplying heat to each of the first reaction device and the second reaction device and a second control signal for supplying heat to only one of the first reaction device and the second reaction device to the heat supplier. The controller selects any one of the first control signal and the second control signal based on the amount of hydrogen included in the source gas.

Effects of Invention

[0009] The hydrocarbon production equipment, the hydrocarbon production system, the controller of the hydrocarbon production device, and the method for producing hydrocarbon can improve energy efficiency in producing hydrocar-

first catalyst heated to a predetermined temperature to generate a first intermediate gas including hydrocarbon; a second reaction device configured to cause the first intermediate gas to react by using a second catalyst heated to a predetermined temperature to generate a second intermediate gas including hydrocarbon; a heat supplier configured to be capable of supplying heat for heating the first catalyst to the first reaction device and capable of supplying heat for heating the second catalyst to the second reaction device; and a controller configured to control an operation of the heat supplier. The controller selectively outputs a first control signal for supplying heat to each of the first reaction device and the second reaction device and a second control signal for supplying heat to only one of the first reaction device and the second reaction device to the heat supplier. The controller selects any one of the first control signal and the second control signal based on the amount of hydrogen included in the source gas.

[0017] When the amount of hydrogen supplied to the hydrocarbon production equipment is small, the heat amount generated by the reaction is also small. As a result, it is necessary to heat the first catalyst and the second catalyst to a temperature required for causing the reaction. The hydrocarbon production equipment switches between an aspect in which a heating medium is supplied to both the first reaction device and the second reaction device and an aspect in which a heating medium is supplied to only one of the first reaction device and the second reaction device based on the amount of hydrogen included in the source gas. As a result, when the amount of hydrogen to be supplied to the hydrocarbon production equipment is small, by adopting the aspect in which a heating medium is supplied to only one of the first reaction device and the second reaction device, the heat amount to be supplied for maintaining the reaction can be reduced. Therefore, the hydrocarbon production equipment can improve energy efficiency in an operation of generating a gas including hydrocarbon from the source gas.

[0018] The heat supplier of the hydrocarbon production equipment may include a heating medium flow path portion through which the heating medium supplied to the first reaction device and the second reaction device flows, and a heat control unit that performs heat exchange with the heating medium. The heating medium flow path portion may include a first heating medium flow path connected to the first reaction device, a second heating medium flow path connecting the first reaction device to the second reaction device, and a third heating medium flow path connected to the second reaction device. According to this configuration, the heating medium supplied with heat in the heat control unit is supplied to the first reaction device and the second reaction device. As a result, the heat amount required for the reaction can be provided to the first catalyst and the second catalyst.

[0019] The heating medium flow path portion of the hydrocarbon production equipment may include: a heating medium bypass flow path configured to connect the second heating medium flow path to the third heating medium flow path; and a heating medium switching unit configured to switch between an aspect of supplying the heating medium to the second reaction device by receiving the first control signal and an aspect of supplying the heating medium to the heating medium bypass flow path without supplying the heating medium to the second reaction device by receiving the second control signal. According to this configuration, switching between the aspect of supplying the heating medium to the second reaction device and the aspect of not supplying the heating medium to the second reaction device can be implemented by a simple configuration.

[0020] The hydrocarbon production equipment may further include: a first gas flow path connected to the first reaction device; a second gas flow path configured to connect the first reaction device to the second reaction device; a third gas flow path connected to the second reaction device; a gas bypass flow path configured to connect the second gas flow path to the third gas flow path; and a gas switching unit configured to switch between an aspect of supplying the first intermediate gas to the second reaction device by receiving the first control signal and an aspect of supplying the first intermediate gas to the gas bypass flow path without supplying the first intermediate gas to the second reaction device by receiving the second control signal. According to this configuration, switching between the aspect of supplying the first intermediate gas to the second reaction device and the aspect of not supplying the first intermediate gas to the second reaction device can be implemented by a simple configuration.

[0021] The controller of the hydrocarbon production equipment may include a hydrogen amount acquisition unit configured to obtain data on the amount of hydrogen included in the source gas, a heat amount comparison unit configured to compare, when the source gas including hydrogen in the amount indicated by the data on the amount of hydrogen is received, a reaction heat amount including a heat amount generated by the reaction of the first reaction device and a heat amount generated by the reaction of the second reaction device with a required heat amount required for maintaining the reaction of the first reaction device and the reaction of the second reaction device, and a signal output unit configured to output the second control signal to the heat supplier when the reaction heat amount is smaller than the required heat amount. According to this controller, it is possible to easily determine a state in which heat is to be supplied to only one of the first reaction device and the second reaction device.

[0022] The first reaction device of the hydrocarbon production equipment described above may include at least two reactors connected in parallel with each other. According to this configuration, the generation amount of the first intermediate gas can be increased.

[0023] A hydrocarbon production system according to another aspect of the present disclosure includes a hydrogen supply equipment configured to output hydrogen, and the hydrocarbon production equipment configured to receive a source gas including hydrogen and carbon and generate a gas including hydrocarbon. The hydrocarbon production equipment includes the first reaction device configured to receive a source gas including hydrogen and carbon and cause the source gas to react by using a first catalyst heated to a predetermined temperature to generate a first intermediate gas including hydrocarbon, the second reaction device configured to cause the first intermediate gas to react by using a second catalyst heated to a predetermined temperature to generate a second intermediate gas including hydrocarbon, the heat supplier configured to supply heat for heating the first catalyst to the first reaction device and supply heat for heating the second catalyst to the second reaction device, and the controller configured to control an operation of the heat supplier. The controller selectively

outputs a first control signal for supplying heat to each of the first reaction device and the second reaction device and a second control signal for supplying heat to only one of the first reaction device and the second reaction device to the heat supplier. The controller selects any one of the first control signal and the second control signal based on the amount of hydrogen included in the source gas.

[0024] The hydrocarbon production system includes the hydrocarbon production equipment described above. Therefore, energy efficiency in an operation of generating a gas including hydrocarbon from the source gas can be improved.

[0025] According to still another aspect of the present disclosure, provided is a controller of a hydrocarbon production device including: a first reaction device configured to receive a source gas including hydrogen and carbon and cause the source gas to react by using a first catalyst heated to a predetermined temperature to generate a first intermediate gas including hydrocarbon; and a second reaction device configured to cause the first intermediate gas to react by using a second catalyst heated to a predetermined temperature to generate a second intermediate gas including hydrocarbon. The controller of the hydrocarbon production device includes: a hydrogen amount acquisition unit configured to obtain data on an amount of the hydrogen included in the source gas; a heat amount comparison unit configured to compare a reaction heat amount including a heat amount generated by a reaction of a first reaction device and a heat amount generated by a reaction of a second reaction device with a required heat amount required for maintaining the reaction of the first reaction device and the reaction of the second reaction device, when the hydrocarbon production device receives a source gas including hydrogen in the amount indicated by the data on the amount of hydrogen; and a signal output unit configured to output a control signal for supplying heat to only one of the first reaction device and the second reaction device to a heat supplier capable of supplying heat for heating the first catalyst to the first reaction device and supplying heat for heating the second catalyst to the second reaction device, when the reaction heat amount is smaller than the required heat amount.

[0026] The controller of the hydrocarbon production device can determine an object to which the heating medium is to be provided based on the amount of hydrogen included in the source gas supplied to the hydrocarbon production device. Therefore, the controller of the hydrocarbon production device can improve energy efficiency in the operation of generating a gas including hydrocarbon from the source gas, the operation which is performed by the hydrocarbon production device.

[0027] According to still another aspect of the present disclosure, provided is a method for producing hydrocarbon by using the hydrocarbon production device including: a first reaction device configured to receive a source gas including hydrogen and carbon and cause the source gas to react by using a first catalyst heated to a predetermined temperature to generate a first intermediate gas including hydrocarbon; and a second reaction device configured to cause the first intermediate gas to react by using a second catalyst heated to a predetermined temperature to generate a second intermediate gas including hydrocarbon. The method for producing hydrocarbon by using the hydrocarbon production device includes: a step of obtaining data on an amount of the hydrogen included in the source gas; a step of comparing a reaction heat amount including a heat amount generated by a reaction of a first reaction device and a heat amount generated by a reaction of a second reaction device with a required heat amount required for maintaining the reaction of the first reaction device and the reaction of the second reaction device, when the hydrocarbon production device receives the source gas including hydrogen in the amount indicated by the data on the amount of hydrogen; and a step of outputting a control signal for supplying heat to only one of the first reaction device and the second reaction device to a heat supplier capable of supplying heat for heating the first catalyst to the first reaction device and supplying heat for heating the second catalyst to the second reaction device, when the reaction heat amount is smaller than the required heat amount.

[0028] In the method for producing hydrocarbon, an object to which the heating medium is to be provided is determined based on the amount of hydrogen included in the source gas supplied to the hydrocarbon production device. Therefore, the method for producing hydrocarbon can improve energy efficiency in the operation of generating a gas including hydrocarbon from the source gas, the operation which is performed by the hydrocarbon production device.

[0029] Hereinafter, the hydrocarbon production equipment, the hydrocarbon production system, the controller of the hydrocarbon production device, and the method for producing hydrocarbon according to the present disclosure are described in detail with reference to the drawings. In the description of the drawings, the same elements and corresponding elements are denoted by the same reference numerals. Further, redundant description may be omitted.

[0030] As illustrated in FIG. **1**, a hydrocarbon production equipment **1** is supplied with a source gas. The hydrocarbon production equipment **1** causes the source gas to react by using a catalyst. As a result, the hydrocarbon production equipment **1** generates a product gas.

[0031] The source gas includes hydrogen gas and carbon dioxide gas. The source gas may include carbon monoxide gas instead of carbon dioxide gas. The hydrocarbon production equipment **1** may include an input **1***a* for receiving hydrogen gas and an input **1***b* for receiving carbon dioxide gas. The hydrocarbon production equipment **1** may have an input for receiving a source gas in which hydrogen gas and carbon dioxide gas are mixed.

[0032] The product gas includes hydrocarbon. The hydrocarbon production equipment **1** outputs the product gas from an output **1***c*.

[0033] The hydrocarbon production equipment **1** is supplied with a hydrogen gas, for example, from a water electrolysis device **101** (hydrogen supply equipment). The water electrolysis device **101** receives power. The water electrolysis device **101** generates hydrogen from water. The power consumed by the water electrolysis device **101** is purchased, for example, from a power company **105**. The power consumed by the water electrolysis device **101** is supplied from a renewable energy equipment **102**. Examples of the renewable energy equipment **102** include a solar power generation equipment using sunlight which is renewable energy. Examples of the renewable energy equipment **102** include a wind power generation equipment using wind power which is renewable energy. The solar power generation equipment and the wind power generation equipment

energy equipment **102** may be an equipment that generates power using other renewable energy.

[0034] In power generation using sunlight or wind power, the power generation amount fluctuates depending on the weather and the time zone. For example, the solar power generation equipment cannot originally generate power at night. In the solar power generation equipment, the power generation amount is greatly reduced in bad weather. Production of hydrogen by the water electrolysis device **101** may be performed by using surplus power. From such circumstances, the power supplied to the water electrolysis device **101** is likely to fluctuate, and as a result, the amount of hydrogen output from the water electrolysis device **101** is also likely to fluctuate. As a result, a timing at which a sufficient amount of hydrogen gas cannot be supplied to the hydrocarbon production equipment **1** occurs.

[0035] Examples of the water electrolysis device **101** include an alkaline water electrolysis device. The minimum load power of the alkaline water electrolysis device may be determined for operational convenience. The alkaline water electrolysis device needs to be supplied with power required for low-load operation. For example, in case of not being supplied with the power from the renewable energy equipment **102**, the alkaline water electrolysis device may be supplied with power from a storage battery. In addition, the alkaline water electrolysis device may be supplied with the power purchased from the power company **105**.

[0036] The hydrocarbon production equipment **1** is further supplied with a hydrogen gas, for example, from a hydrogen storage equipment **103** (hydrogen supply equipment). The hydrogen stored in the hydrogen storage equipment **103** may be surplus hydrogen output from the water electrolysis device **101**. The hydrogen stored in the hydrogen storage equipment **103** may be hydrogen transported from the outside.

[0037] The hydrocarbon production equipment **1** is supplied with carbon dioxide gas. The carbon dioxide gas is supplied, for example, from a carbon dioxide recovery equipment **104**. The hydrocarbon production equipment **1** receives carbon dioxide gas from the input **1***b*.

[0038] A configuration including the hydrocarbon production equipment **1** and at least one of the water electrolysis device **101** and the hydrogen storage equipment **103** is referred to as a hydrocarbon production system **100**. The hydrocarbon production system **100** may include the other one of the water electrolysis device **101** and the hydrogen storage equipment **103**, and the carbon dioxide recovery equipment **104**. In short, the hydrocarbon production system **100** means a system that includes the hydrocarbon production equipment **1** and an equipment for supplying a raw material to the hydrocarbon production equipment **1**.

[0039] The hydrocarbon production equipment **1** includes a hydrocarbon production device **2** and a controller **3** (controller). The hydrocarbon production device **2** generates a product gas from a source gas. The controller **3** controls the hydrocarbon production device **2**. The controller **3** may be connected to the hydrocarbon production device **2** so as to be able to transmit a control signal θ. The control signal θ may be transmitted by wired communication. The control signal θ may be transmitted by wireless communication. The controller **3** may be disposed near the hydrocarbon production device **2**. The controller **3** may be disposed away from the hydrocarbon production device **2**. Details of the controller **3** are described below.

[0040] The hydrocarbon production device **2** includes a first reaction device **21**S, a second reaction device **22**S, a third reaction device **23**S, and a heat supplier **24**. The first reaction device **21**S includes one reactor **21**. Similarly, the second reaction device **22**S also includes one reactor **22**. The third reaction device **23**S includes one reactor **23**. The reaction device according to the present disclosure includes one reactor. The number of reactors configuring the reaction device is not limited to one. The reaction device may be configured with at least two reactors. Modifications of the reaction device are described below.

[0041] The first reaction device **21**S, the second reaction device **22**S, and the third reaction device **23**S generate a gas including hydrocarbon by causing the source gas to react by using a catalyst. The first reaction device **21**S, the second reaction device **22**S, and the third reaction device **23**S are connected to each other by a plurality of gas pipes.

[0042] Schematically, the first reaction device **21**S, the second reaction device **22**S, and the third reaction device **23**S are connected in series in this order. The first reaction device **21**S receives hydrogen gas from the input **1***a* and also receives carbon dioxide gas from the input **1***b*. The first reaction device **21**S provides a first intermediate gas generated as a result to the second reaction device **22**S. The second reaction device **22**S receives the first intermediate gas. The second reaction device **22**S generates a second intermediate gas from the first intermediate gas. The second intermediate gas has a larger proportion of hydrocarbon than the first intermediate gas. The second reaction device **22**S provides the second intermediate gas to the third reaction device **23**S. The third reaction device **23**S receives the second intermediate gas. The third reaction device **23**S generates the product gas from the second intermediate gas. The product gas has a larger proportion of hydrocarbon than the second intermediate gas. Finally, the third reaction device **23**S provides the product gas to the outside from the output **1***c*.

[0043] The above-described gas flow is implemented by a gas flow path portion **25**. The gas flow path portion **25** includes a first gas pipe **251** (first gas flow path), a second gas pipe **252** (second gas flow path), a third gas pipe **253** (third gas flow path), and a fourth gas pipe **254**. The first gas pipe **251** connects the input **1***a* and the input **1***b* to the first reaction device **21**S. The second gas pipe **252** connects the first reaction device **21**S to the second reaction device **22**S. The third gas pipe **253** connects the second reaction device **22**S to the third reaction device **23**S. The fourth gas pipe **254** connects the third reaction device **23**S to the output **1***c*.

[0044] The first reaction device **21**S, the second reaction device **22**S, and the third reaction device **23**S have a difference in performance such as an acceptable gas volume but basically have a similar structure. The first reaction device **21**S synthesizes hydrocarbon by using hydrogen gas and carbon dioxide gas as raw materials. Examples of the reaction for synthesizing a hydrocarbon synthetic product from carbon dioxide include methanation represented by Formula (1). Examples of the reaction for synthesizing a hydrocarbon synthetic product from carbon dioxide include FT synthesis represented by Formula (2).

$$CO_2+4H_2\rightarrow CH_4+2H_2O \quad (1)$$

$$nCO_2+3nH_2\rightarrow\text{—}(CH_2)\text{-}n+2nH_2O \quad (2)$$

[0045] Methanation and FT synthesis generally react at a high temperature of 200° C. or higher by using a catalyst. In

order to use a catalyst having activity at a high temperature, it is necessary to preheat the catalyst to a high temperature state by using a heating medium HM in advance. Examples of the heating medium HM include oil, water vapor, and molten salt. In the case of heating the catalyst to a temperature required for the reaction, when heating with the heating medium HM is adopted, it takes about several hours to 24 hours depending on the capacity of the hydrocarbon reactor. Therefore, after the temperature of the catalyst is raised to the temperature required for the reaction, the catalyst is generally maintained in a high temperature state.

[0046] FIG. **2** is an example of an internal structure of the reactor **21** included in the first reaction device **21**S. The reactor **21** includes a shell **211**, a plurality of tubes **212**, and a buffer **213**. The shell **211** configures an outer shell of the reactor **21**. The shell **211** includes a gas inlet **211***a*, a gas outlet **211***b*, a heating medium inlet **211***c*, and a heating medium outlet **211***d*.

[redacted]

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[0047] The gas inlet **211***a* is connected to the gas outlet **211***b* by the plurality of tubes **212**. A catalyst CT (first catalyst) is disposed inside the tube **212**. When the source gas passes through the catalyst CT disposed in the tube **212**, a reaction occurs. As a result, a gas including hydrocarbon is generated. The heating medium inlet **211***e* is connected to the heating medium outlet **211***d* via a space surrounded by the shell **211**, the tubes **212**, and partition walls **215**. An area through which the gas flows and an area through which the heating medium HM flows are separated by the tubes **212** and the partition walls **215**.

[0048] The heating medium HM flows from the heating medium inlet **211***c* to the heating medium outlet **211***d* while being in contact with the outer peripheral surface of the tube **212**. In the process of flowing from the heating medium inlet **211***c* to the heating medium outlet **211***d*, the heat exchange between the heating medium HM and the catalyst CT is

medium HM, the catalyst CT included in the first reaction device **21**S, the second reaction device **22**S, and the third reaction device **23**S can be maintained at a predetermined temperature.

[0050] The heat supplier **24** includes a heat controller **241** (heat control unit) and a heating medium flow path portion **242**. The heat supplier **24** is allowed to include components different from the heat controller **241** and the heating medium flow path portion **242**.

[0051] The heat controller **241** has a function of applying heat to the heating medium HM and a function of taking heat from the heating medium HM. The heat controller **241** may include a heater **241***a* for the function of applying heat to the heating medium HM. The heat controller **241** may include a heat exchanger **241***b* for the function of taking heat from the heating medium HM. For example, the heat exchanger **241***b* may be a cooler. The heat controller **241** may include a pump **241***c* for moving the heating medium HM. For example, as illustrated in FIG. **1**, the heat exchanger **241***b*, the pump **241***c*, and the heater **241***a* may be connected in this order along the direction in which the heating medium HM flows. Both the methanation represented by Formula (1) and the FT reaction represented by Formula (2) are exothermic reactions. When the reaction starts, the temperature of the catalyst CT rapidly rises. Therefore, it is necessary to control the temperature so that the temperature of the catalyst CT is kept within a predetermined range by taking the generated heat amount. The heat controller **241** can also be used for heat control for keeping the temperature of the catalyst CT within a predetermined range.

[0052] The heating medium flow path portion **242** includes a first heating medium pipe **242***a* (first heating medium flow path), a second heating medium pipe **242***b* (second heating medium flow path), a third heating medium pipe **242***c* (third heating medium flow path), and a fourth